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# Road vehicles — Environmental conditions and testing for electrical and electronic equipment for drive system of electric propulsion vehicles —

## Part 1: General

*Véhicules routiers — Spécifications d'environnement et essais de l'équipement électrique et électronique pour les véhicules à propulsion électrique —*

*Partie 1: Généralités*



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# Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 32, *Electrical and electronic components and general system aspects*.

A list of all parts in the ISO 19453 series can be found on the ISO website.



# Introduction

The purpose of ISO 19453 is to assist its user in systematically defining and/or applying a set of internationally accepted environmental conditions, tests and operating requirements based on the anticipated actual environment which the equipment will be operated in and exposed to during its life cycle. This document has been developed based on fundamental investigations and vehicle measurements on voltage class B components. Therefore, its scope is restricted to such components. However, this document can also be referred to for testing components such as electric motors, inverters and DC/DC converters used in supply voltage classes other than voltage class B if its applicability has been verified by, for example, vehicle measurements. The ISO 19453 series is based on the ISO 16750 series and follows the same basic principles, but is dedicated to voltage class B components.

Contrary to the ISO 16750 series, the ISO 19453 series contains no part 2 on electrical testing as those testing conditions and requirements are handled in ISO 21498.

The following environmental factors have been considered in the development of this document.

— World geography and climate

Electric propulsion vehicles are operated in nearly all land regions of the earth. Significant variations in environmental conditions due to climatic environment, including diurnal and seasonal cycles, can therefore be expected. Consideration has been given to worldwide ranges in temperature, humidity, precipitation and atmospheric conditions including dust, pollution and altitude.

— Type of electric propulsion vehicle

Environmental conditions in and on electric propulsion vehicles can depend on vehicle design attributes, such as whether to equip an internal combustion engine and/or an electric motor for vehicle propulsion, vehicle mass, vehicle size, electrical supply voltage and so on. Consideration has been given to typical series production electric propulsion vehicles, including hybrid electric vehicles, battery electric vehicles, range extender hybrid electric vehicles and fuel cell vehicles, but not including the equipment specific for fuel cell systems.

— Vehicle use conditions and operating modes

Environmental conditions in and on the vehicle vary significantly with road quality, types of road surface, road topography, vehicle use (e.g. commuting, towing, cargo transport, etc.) and driving habits. Operating modes such as storage, starting, driving, stopping and so on have been considered. Additionally, it has been taken into account that combustion engine speed distributions differ significantly for hybrid vehicles with electric driving modes during which the internal combustion engine is completely shut off.

— Equipment life cycle

Electrical and electronic equipment is also resistant to environmental conditions experienced during manufacture, shipping, handling, storage, vehicle assembly and vehicle maintenance and repair. Such conditions and tests (e.g. handling drop test) are within the scope of this document.

— Vehicle supply voltage

For electrical and electronic equipment with different supply voltages, these voltages are considered for the specification of operating modes applied for testing.

— Component mass and volume

Current components of the drive system of electrically propelled road vehicles tend to be much larger and heavier than conventional, small and light E/E equipment for which the test conditions are covered by the ISO 16750 series. The size and mass of components of the electric powertrain have been considered in this ISO 19453 series, for example, by taking the inertia mass of those components into account as an effect on the measured excitation during vibration measurements. Also, the size and mass significantly influence the necessary dwell time at low and high temperatures when applying a thermal

profile, such as in ISO 19453-4, as it takes much longer to reach the intended temperature in the core of the component.

— Mounting location in the vehicle

In current or future vehicle concepts, systems/components are mounted in almost any location of the vehicle. The environmental requirements for each specific application highly depend on its mounting location. Each location in a vehicle has its distinct set of environmental loads. As an example, the range of temperatures in the engine compartment differs significantly from the range in the passenger compartment. This is also true for the vibration loads, except that in this case, not only are the vibration levels different, but the type of vibration load also varies. Body mounted components are typically exposed to random vibrations whereas for engine mounted systems/components the additional sine vibration from the engine is considered. Moreover, devices installed in doors are exposed to a high number of mechanical shocks from door slamming.

It is desirable for the vehicle manufacturer to group the different environmental load types and levels in a reasonable number of standard requirement sets. This strategy makes it possible to carry systems/components from one vehicle project to another. Furthermore, the exact requirement levels are often unknown when designing a component for a future vehicle concept. The expected environmental loads are usually compiled from other vehicle concepts with similar conditions. The grouping is normally done by mounting location, but it is difficult to define the right number of different mounting locations and respective load profiles, because there is a conflict of aims between having only few requirement classes and tailoring the requirement levels to each application. The reason is that the environmental loads are not only depending on the mounting location. There are other major factors that affect the stress levels for systems/components. For example, body styles, drive-train concepts or package densities can create absolutely different requirement levels for devices that are installed in different vehicles at almost the same location.

The purpose of ISO 19453 is to define requirement classes for separate load types. It distinguishes between electrical, mechanical, thermal, climatic and chemical loads. For each load type, several requirement classes are defined. Every requirement class is determined by a specific code letter. The complete environmental requirement set is created by defining the code letter combination. The code letters are defined in the respective clauses of this document. Additionally, tables in the annexes of each part show the usual mounting locations and give examples of their respective code letters. For normal applications, these code letters are used. If an application is very specific and therefore the given code letter combinations cannot be used, it is possible to create new code letter combinations to serve this purpose. In case none of the given code letters is useable, new requirement levels can be created by using the code letter Z. In this case, the specific requirements are defined separately, but it is desirable not to change the test methods.

At a minimum, the following mounting locations should be considered for a device under test (DUT) with respect to thermal, mechanical, climatic and chemical loads.

a) Applicability to manufacturer's responsibility

Due to technology limitations or variations in vehicle design, the vehicle manufacturer can be required to place a component in a location where it cannot withstand the environmental conditions described in ISO 19453. Under these circumstances, it is the responsibility of the vehicle manufacturer to provide the necessary environmental protection.

b) Applicability to wiring harnesses, cables and electrical connectors

Although some environmental conditions and tests in ISO 19453 can be relevant to vehicle wiring harnesses, cables and connectors, its scope is not sufficient to be used as a complete standard. It is therefore not recommended that ISO 19453 be directly applied to such devices and equipment.

c) Applicability to parts or assemblies inside equipment

ISO 19453 describes environmental conditions and tests to be applied to electrical and electronic equipment directly mounted in or on the vehicle. It is not intended for direct application to parts or assemblies that are part of the equipment. For example, ISO 19453 should not be directly applied to



integrated circuits (ICs) and discrete components, electrical connectors, printed circuit boards (PCBs), gauges, etc. that are attached in or on the equipment. Electrical, mechanical, climatic and chemical loads for such parts and assemblies can be quite different from those described in ISO 19453. Therefore, for those sub-components, the test conditions of ISO 16750 can be considered as a reference.

On the other hand, it is desirable to use ISO 19453 to help derive environmental conditions and test requirements for parts and assemblies that are intended for use in road vehicle equipment. For example, a temperature range of −40 °C to 90 °C may be specified for an assembly contained inside a piece of equipment having a temperature range of −40 °C to 70 °C and an additional temperature rise of 20 K.

d) Applicability relative to system integration and validation

The user of ISO 19453 is cautioned to understand that the scope of ISO 19453 is limited to conditions and testing at the equipment level, and therefore does not represent all conditions and testing necessary for complete verification and validation of the vehicle system. Environmental and reliability testing of equipment parts and vehicle systems can be required.

For example, ISO 19453 does not necessarily ensure that environmental and reliability requirements for solder joints, solderless connections, integrated circuits and so on are met. Such items are ensured at the part, material or assembly level. Additionally, vehicle and system level testing can be required to validate the equipment in the vehicle application.

# Road vehicles — Environmental conditions and testing for electrical and electronic equipment for drive system of electric propulsion vehicles —

# Part 1: General



## 1 Scope

This document specifies requirements for the electric propulsion systems and components with maximum working voltages according to voltage class B. It does not apply to high voltage battery packs (e.g. for traction) and systems or components inside. It describes the potential environmental stresses and specifies tests and requirements recommended for different stress levels on/in the vehicle.

This document contains definitions and general requirements. Like all other parts of the 19453 series, it is not intended to apply to environmental requirements or testing for:

— wiring harnesses, cables and electrical connectors;

— parts or assemblies inside an equipment, if not otherwise specified;

— system integration of equipment and system validation on vehicle level, if not otherwise specified in a test requirement.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 6469-3, *Electrically propelled road vehicles — Safety specifications — Part 3: Protection of persons against electric shock*

ISO 16750-1, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 1: General*

ISO 19453-3, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment for drive system of electric propulsion vehicles — Part 3: Mechanical loads*

ISO 19453-4, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment for drive system of electric propulsion vehicles — Part 4: Climatic loads*

ISO 19453-5, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment for drive system of electric propulsion vehicles — Part 5: Chemical loads*

ISO 20653, *Road vehicles — Degrees of protection (IP code) — Protection of electrical equipment against foreign objects, water and access*

ISO/PAS 19295, *Electrically propelled road vehicles — Specification of voltage sub-classes for voltage class B*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 16750-1 and ISO/PAS 19295, and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp

**3.1**
**voltage class A**
classification of an electric component or circuit with a maximum working voltage of less than 30 V a.c. (RMS) or 60 V d.c.

**3.2**
**voltage class B**
classification of an electric component or circuit with a maximum working voltage between 30 V a.c. (RMS) and 1 000 V a.c. (RMS) or between 60 V d.c. and 1 500 V d.c.

**3.3**
**electric propulsion system**
combination of traction motor, power electronics and their associated controls for the conversion of electric to mechanical power and vice versa

Note 1 to entry: This term is used as a synonym for "electric drive" (see ISO 6469-1).

**3.4**
**electric propulsion vehicle**
vehicle with one or more *electric propulsion system*(s) (3.3) for vehicle propulsion

Note 1 to entry: This term is used as a synonym for "electrically propelled vehicle" (see ISO 6469-1).

**3.5**
**customer**
party that is interested in using a voltage class B component or system

**3.6**
**supplier**
party that provides a voltage class B component or system

## 4 Classification by mounting location

### 4.1 Powertrain

Device mounted:

— to the body;

— to the frame;

— on the flexible plenum chamber, not rigidly attached;

— in the flexible plenum chamber, not rigidly attached;

— on the engine;

— in the engine;

— on the transmission/retarder;

— in the transmission/retarder;

— on the electric motor;

— in the electric motor.

### 4.2 Passenger compartment

Device mounted in a position:

— without special requirements;

— exposed to direct solar radiation;

— exposed to radiated heat (other than solar radiation).

### 4.3 Luggage compartment/load compartment

Device mounted inside.

### 4.4 Mounting on exterior/in cavities

Device mounted:

— to the body;

— to the frame;

— to underbody/wheel housing;

  1) sprung masses;

  2) unsprung masses (wheel, wheel bracket, axle);

— in/on a passenger compartment door;

— to the engine compartment cover;

— to the luggage compartment lid/door;

— to the trunk lid/door;

— in cavities:

  1) open towards exterior;

  2) open towards interior;

— in special compartment (e.g. battery box).

### 4.5 Other mounting location

For some locations with special environmental conditions (e.g. exhaust system), no standard specifications can be given. In these cases, the load shall be stated in the specification of the device.

# 5 Operating modes

## 5.1 Operating mode 1

No voltage is applied to the device under test (DUT).

— Operating mode 1.1: not connected to wiring harness.

— Operating mode 1.2: connected to wiring harness simulating vehicle installation.

## 5.2 Operating mode 2

The DUT is electrically operated with a test voltage $U_B$ as in a vehicle with shut-off combustion engine, high voltage battery (DC/DC) disconnected and all electrical connections made.

— Operating mode 2.1: system/component functions are not activated (e.g. sleep mode).

— Operating mode 2.2: systems/components with electric operation of voltage class A and control in typical operating mode.

## 5.3 Operating mode 3

The DUT is electrically operated with test voltages $U_A$ and $U_X$ with all electrical connections made.

— Operating mode 3.1: system/component functions are not activated.

— Operating mode 3.2: systems/components with electric operation of voltage class A and B and control in an operating mode in which separate cooling supply is not needed.

## 5.4 Operating mode 4

The DUT is electrically operated with test voltages $U_A$ and $U_X$ with all electrical connections made and with an auxiliary machine, e.g. cooling system, etc.

— Operating mode 4.1: system/component functions are not activated.

— Operating mode 4.2: systems/components with electric operation of voltage class A and B and control in typical operating mode.

# 6 Functional status classification

## 6.1 General

This element describes the functional status of a DUT during and after a test.

The minimum functional status shall be given in each test. An additional test requirement may be agreed between the supplier and the vehicle manufacturer.

Unwanted operations of the DUT are not allowed in any of the following classes (see 6.2 to 6.6).

Electrical safety in accordance with ISO 6469-3 shall be maintained in all of the following classes except class E in which the DUT shall be handled with special care.

## 6.2 Class A

All functions of the device/system perform as designed during and after the test.



### 6.3 Class B

All functions of the device/system perform as designed during the test. However, one or more of them may go beyond the specified tolerance. All functions automatically return to within normal limits after the test. Memory functions shall remain in class A.

The vehicle manufacturer specifies which functions of the DUT must perform as designed during the test and which functions can be beyond the specified tolerance.

### 6.4 Class C

One or more functions of a device/system do not perform as designed during the test, but automatically return to normal operation after the test.

### 6.5 Class D

One or more functions of a device/system do not perform as designed during the test and do not return to normal operation after the test until the device/system is reset by a simple "operator/use" action.

### 6.6 Class E

One or more functions of a device/system do not perform as designed during and after the test and cannot be returned to proper operation without repairing or replacing the device/system.

## 7 Tests and requirements

### 7.1 General

The values specified in ISO 19453-3 to ISO 19453-5 are applied as basic requirements.

DUTs with several mounting locations shall be tested to meet the strictest requirements.

### 7.2 General test conditions

Unless otherwise specified, all tests shall be performed at a room temperature (RT) of (23 ± 5) °C and a relative humidity of 25 % to 75 %.

The test voltages shall be as shown in Table 1, unless other values are specified in the relevant parts of ISO 19453 or are agreed upon by the users of ISO 19453, in which case such values shall be documented in the test reports.

**Table 1 — Test voltages for operating modes 2 to 4 (see 5.2 to 5.4)**

| Test voltage | 12 V system<br>V | 24 V system<br>V | Voltage class B system |
|---|---|---|---|
| $U_A$ | 14 ± 0,2 | 28 ± 0,2 | — |
| $U_B$ | 12 ± 0,2 | 24 ± 0,2 | — |
| $U_X$ | — | — | Voltage for unlimited operating capability[a] ±1 % |

[a] The voltage for unlimited operating capability is specified by the agreement between the customer and the supplier in accordance with ISO/PAS 19295.

### 7.3 Test sequence

Prior to testing, a test procedure plan shall be agreed upon, stating the type, number, programme/group of tests to be conducted in sequence or in parallel by consideration of the economy and duration of testing.

A life test shall be defined specifically for the product and be taken into account in the test sequence plan.

An example is given in Annex A.

## 8 Designation

### 8.1 Coding

Figure 1 describes the referred tests for the device(s) by a code form for technical specifications and/or other documentation. The different elements of the code shall be in accordance with the relevant documents as mentioned in Figure 1.

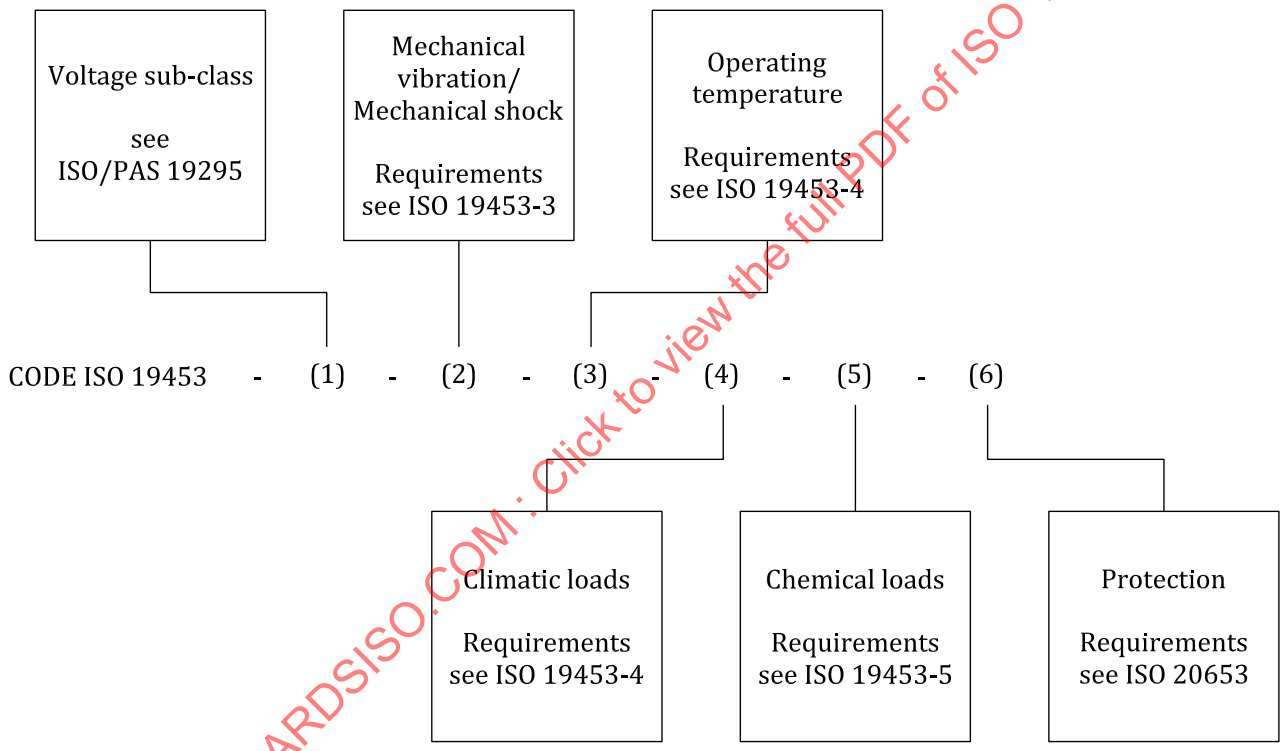



**Figure 1 — Code allocation**



EXAMPLE ISO 19453-B_470-A-Ha-A-A-IP6K9K.

This example shows the designation of an environmental requirement for a system/component with:

— a voltage sub-class as defined in code B_470 in ISO/PAS 19295;

— a mechanical load requirement as defined in code letter A in ISO 19453-3;

— an operating temperature requirement as defined in code letter Ha in ISO 19453-4;

— a climatic load requirement as defined in code letter A in ISO 19453-4;

— a chemical load requirement as defined in code letter A in ISO 19453-5;

— a degree of protection IP6K9K in accordance with ISO 20653.

## 8.2 Use of Code Z "as agreed"

ISO 19453 accommodates special needs and situations through the use of Code Z "as agreed". The use of Code Z should be restricted to cases in which the supplier and/or customer determine that the conditions or tests defined in ISO 19453 are:

— not suitable to achieve desired product quality/reliability objectives; and/or

— not practical.

When Code Z "as agreed" is used, the following requirements and recommendations apply:

— the rationale (reason) for not using the provided conditions or tests shall be documented;

— a complete description of the "as agreed" condition or test should be documented;

— data and the rationale supporting the suitability of the "as agreed" condition or test shall be documented;

— any specific information regarding Code Z "as agreed" contained in ISO 19453-3 to ISO 19453-5 shall be documented;

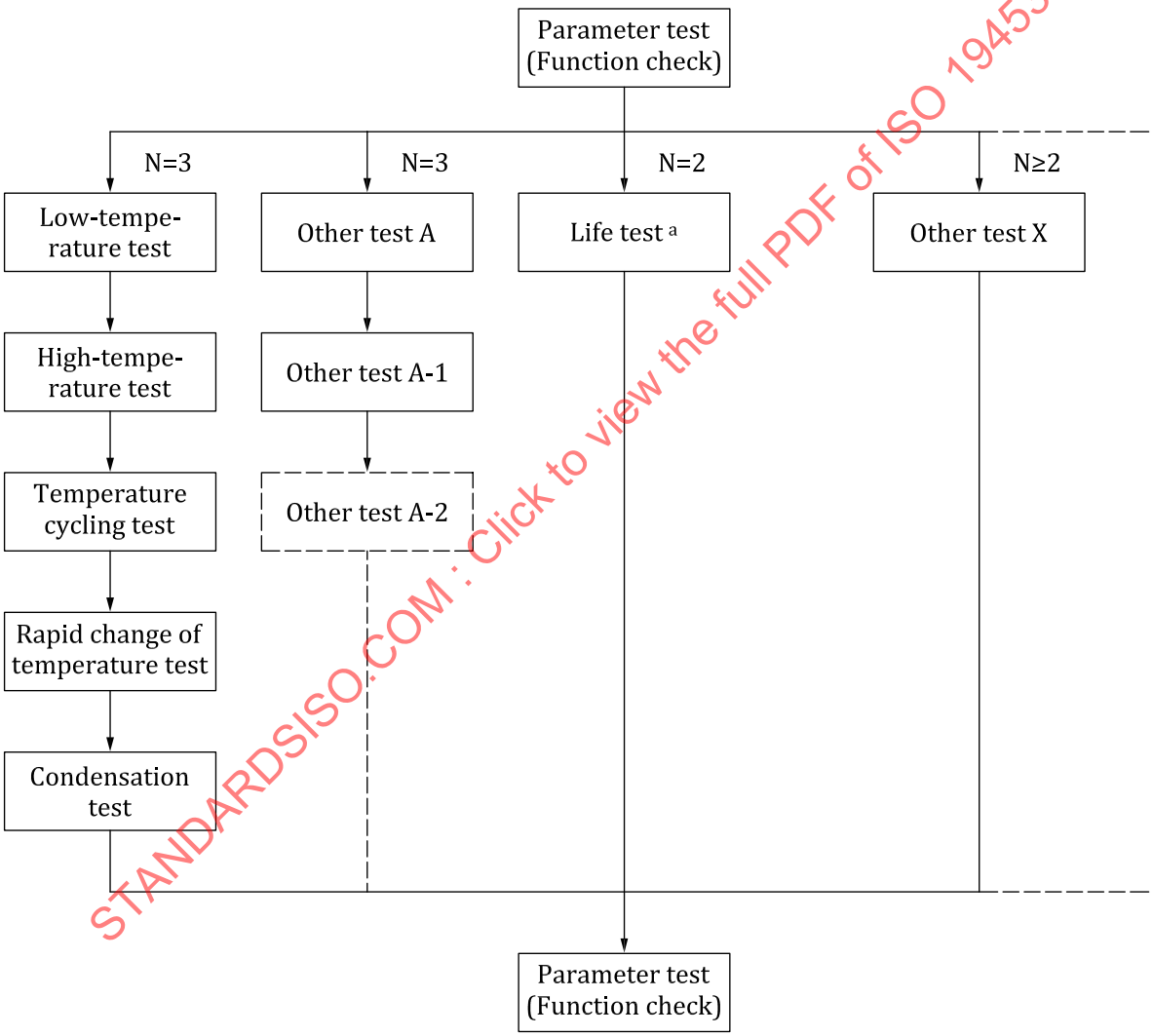
— the equipment supplier and customer shall agree that the "as agreed" documentation is adequate.

# Annex A
(informative)

# Example of a test plan

Figure A.1 shows a test procedure plan, only as an example. It is not intended to be carried over as an exact template for an actual test plan. Depending on the failure mechanisms of an individual component, a suitable test sequence needs to be designed.

Individual test sequences can be conducted in parallel by consideration of the economy and duration of testing.




a See Annex B.

**Figure A.1 — Test plan (example)**

# Annex B
(informative)

# Example of life test/reliability statement

## B.1 General

In addition to environmental loads, a product used in the vehicle will be subjected to loads induced by its own function, hereafter referred to as functional loads.

The loads are simulated by life tests, which generally comprise a combination of functional loads and relevant environmental loads occurring simultaneously.

These tests are performed according to programmes derived from in-practice operation.

## B.2 Aim of life tests

### B.2.1 General

Two fundamentally different cases are to be distinguished, depending on the type of problem.

### B.2.2 Potential design weakness

Using real-time life tests or accelerated life tests (with corresponding load increase), the design can be checked for functional loads combined with further environmental loads in order to discover design weaknesses. Generally, only a small number of DUTs will suffice to achieve this. This case is by far the most frequent. However, the results are not suitable for deriving a statement on reliability as the number of DUTs is too low for a statistically correct statement.

### B.2.3 Reliability

Determining reliability is a totally different task. The following step-by-step method is suggested:

a) Determine the type of load which is relevant for service life and specific to the product and determine the test to be conducted.

b) Determine the in-practice load, for example running time, mean temperature, etc.

c) Specify the survival probability and confidence levels and calculate the necessary number of DUTs or test duration on the basis of in-practice load, based on statistical correlation. Generally, this calculation requires extensive testing.

d) A reduction of this extensive testing resulting from step c) to feasible values can be performed by a permissible increase of load on the basis of an appropriate correlation between in-practice experience and testing. The increase in load cannot lead to a change of the expected damage process. Generally, compared to the check of potential design weaknesses, considerably more extensive testing will be required.

The step-by-step method should also be used in the first case for checking design; however, step c) is omitted (statistics calculation).